Logistics Reduction: Advanced Clothing System (ACS) (LR-ACS)

Active Technology Project (2014 - 2024)

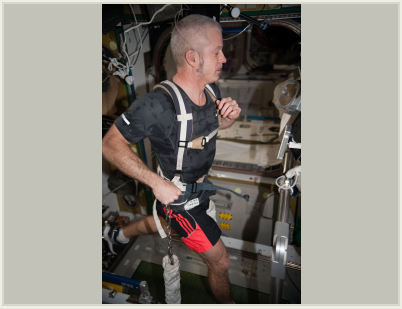
Project Introduction

The goals of the Exploration Capabilities (EC) Logistics Reduction (LR) project's Advanced Clothing System (ACS) element are to reduce mass and volume of the clothing system and to meet new requirements for textiles for exploration missions. Advanced commercial off-the-shelf fibers (COTS) and treatments can be leveraged to directly reduce the mass and volume of astronaut clothing. The textile industry has made significant progress with new fiber blends and garment finishing. The ACS team is also working on new ways to efficiently clean clothing and other textiles in mission as a way to reduce the burden of resupplying new, clean clothes. An example of new requirements for the ACS team to address is achieving fire safety for textiles in higher oxygen atmospheres expected in planetary missions.

The current clothing state-of-the-art on the International Space Station (ISS) is disposable, mostly cotton-based, clothing with no laundry provisions. Each clothing article has varying use periods and will become trash. The goal is to increase the length of wear of the clothing to reduce the logistical mass and volume.

The ACS technology is a continuation from the Logistics Reduction and Repurposing project (https://techport.nasa.gov/view/10577). The initial focus was exercise clothing and routine wear tops since the use period is shorter. A ground-based experiment was conducted to evaluate current and lighter weight COTS exercise clothing and antimicrobial treatments to investigate if they could be used for longer periods of time. The best performers were selected for an experiment on the International Space Station (ISS) - Intravehicular Activity (IVA) Clothing Study. The experiment was conducted during ISS increments 39 through 41 with six crew members. A laundry trade-off study was conducted to quantify how longer-wear clothing changes the break-even point for laundering vs. clothing disposal. The analysis indicates that use of ACS selected garments (e.g. wool, modacrylic, polyester) can increase the breakeven point for laundry to about 300 days. Past ACS studies also investigated lint reduction and microbial behavior on textiles. Several SBIR companies have investigated coatings to improve wear and laundering of clothing.

In FY20 RFID Clothing tags were selected for clothing demo and data collection in long-term testing opportunities. In FY20 - FY22, the project worked under a Space Act Agreement (SAA) with an industry leader in hygiene products to develop the best cleaning agent for use in space laundry (applies to planetary or microgravity missions, though the washing machine hardware will likely be different.) Other work includes comparing laundry with low- or no-water clothes “freshening” technologies. In early FY22, wastewater and specially formulated detergent were successfully processed in prototype lunar bioreactors. Later in FY22, there is a planned demonstration of clothing/textile stain treatment on ISS by our SAA industry partner.



Astronaut Steve Swanson exercising in IVA Clothing Study shirt and shorts

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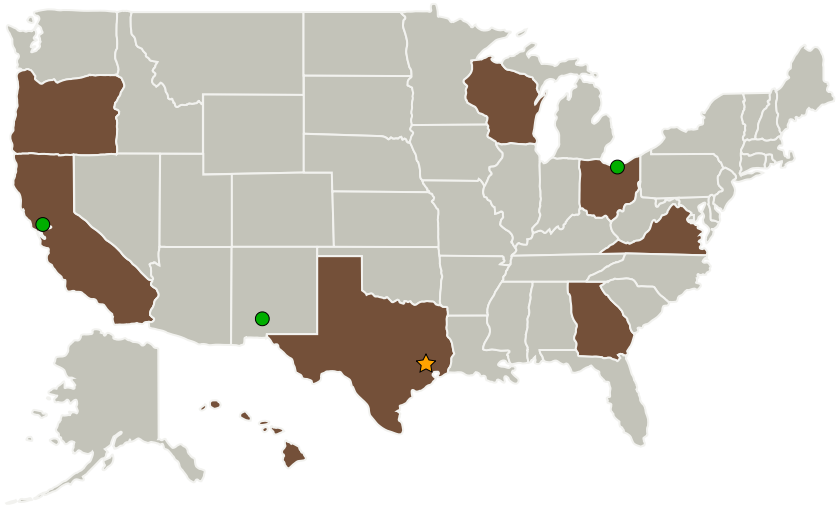
Since FY21 the SBIR program has been used to accelerate development of textiles for the higher oxygen environments planned for Artemis missions. LR also completed a phase IIE extension of the SBIR "Electrochemical Peroxide Generation" with Faraday Technology, Inc. By generating hydrogen peroxide in situ, mass of disposable disinfectant wipes can be reduced by launching them dry and wetting on-orbit. Ultimately, this technology could lead to reusable wipes when a clothes-washing system is available.

Anticipated Benefits

Advanced Clothing Systems would benefit any long-duration operation with limited logistics transportation or stowage capacity. This is accomplished by extending the use of clothing before it has to be laundered or replaced. For a crew of four over one year, using long-wear fabrics could reduce the number of clothing articles required and save approximately 80 kg and 0.2 cubic meters of volume. Further in the future, as clothes cleaning systems are developed for space, even greater savings will be achieved for long missions through the ability to wash and reuse clothing. This will also reduce the burden of disposing dirty clothes after wearing them only a few times.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Exploration Capabilities

Project Management

Program Director:

Christopher L Moore

Project Managers:

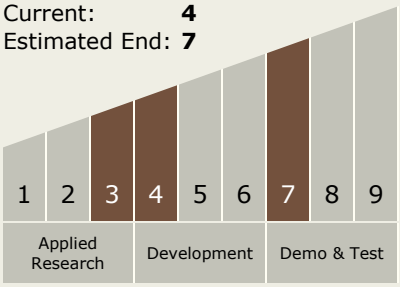
Michael K Ewert
Melissa K Mckinley

Principal Investigator:

Evelyne S Orndoff

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **7**



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Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
●Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
●White Sands Test Facility(WSTF)	Supporting Organization	NASA Facility	Las Cruces, New Mexico

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems
    - TX06.1.4 Habitation Systems

Target Destinations

Earth, The Moon, Mars

Supported Mission Type

Planned Mission (Pull)

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Co-Funding Partners	Type	Location
CarbTex	Industry	Lake Jackson, Texas
Cornell University	Academia	Ithaca, New York
Faraday Technology, Inc	Industry	Clayton, Ohio
Materials Modification, Inc.	Industry Small Disadvantaged Business (SDB)	Fairfax, Virginia
Orbital Technologies Corporation	Industry Women-Owned Small Business (WOSB)	Madison, Wisconsin
Roscosmos	International	Moscow, Outside the United States, Russian Federation
Texas A & M University-College Station(Texas A&M)	Academia Hispanic Serving Institutions (HSI)	College Station, Texas
UMPQUA Research Company	Industry	Myrtle Creek, Oregon
University of Hawaii Maui College	Academia Alaska Native and Native Hawaiian Serving Institutions (ANNH), Asian American Native American Pacific Islander (AANAPISI)	Kahului, Hawaii
Zono Services, LLC	Industry	Lawrenceville, Georgia

Primary U.S. Work Locations	
California	Georgia
Hawaii	Ohio
Oregon	Texas
Virginia	Wisconsin

Images

IVA Clothing Study
Increment 40 crew members in their IVA Clothing Study exercise clothing
(https://techport.nasa.gov/image/143270)

IVA Clothing Study
Astronaut Steve Swanson exercising in IVA Clothing Study shirt and shorts
(https://techport.nasa.gov/image/143271)